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HYPHALION SAGAMIENSE, A NEW SPECIES OF CLAUSIDIIDAE (COPEPODA: POECILOSTOMATOIDA) ASSOCIATED WITH A VESICOMYID BIVALVE FROM THE HATSUSHIMA COLD-SEEP SITE IN SAGAMI BAY, JAPAN

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Abstract.—A new clausidiid copepod, *Hyphalion sagamiense,* found in association with a vesicomyid bivalve, *Calyptogena soyoae* Okutani, 1957, at a depth of 1170 m from the Hatsushima cold-seep site in Sagami Bay, Japan, is described. The species is morphologically very close to its only congener *Hyphalion captans* Humes, 1987 from Guaymas Basin, Gulf of California. The new copepod is distinguished from *H. captans* by the presence of 7-segmented first antenna, spinose paragnath, 5th leg with 2 broad segments, and in the male by a delicate seta on the long terminal claw of the 3-segmented maxilliped. Discovery of the present new species requires an amendment of the generic definition.

In recent years, a large number of new copepods have been described from deep-sea hydrothermal vents and cold-seep sites in the eastern Pacific and the Atlantic (Humes & Dojiri 1980a, 1980b; Fleminger 1983; Humes 1984, 1987, 1988a, 1988b, 1988c, 1988d, 1989a, 1989b, 1989c, 1989d). On the other hand, little is known of the copepods living at vents and/or seep sites in the western Pacific. The only work is one by Humes (1990) who described two new species from a deep-sea hydrothermal vent at the Mariana Back-Arc Basin.

A series of dives by the deep-sea submersible *Shinkai 2000* of the Japan Marine Science and Technology Center (JAMSTEC) have been made for multiple purposes at the Hatsushima cold-seep site which is characterized by the dominant occurrence of *Calyptogena soyoae* Okutani, 1957, since 1984 (Okutani & Egawa 1985). During Dive 315 of 1987, more than 40 specimens of this vesicomyid bivalve were collected and the animals associated with this mollusk were examined. A polychaete and a copepod species were found in the mantle cavity (Miura 1988), and the former was recently described (Miura & Laubier 1990). The purpose of this paper is to describe the parasitic copepod. The new copepod species is morphologically very close to *Hyphalion captans* Humes, 1987 collected from Guaymas Basin, Gulf of California; however, some unique characters in the new copepod support the establishment of a new taxon and require a minor emendation of the original diagnosis of the genus.

Materials and Methods

Calyptogena soyoae, hosts of the copepods, were collected during *Shinkai 2000* Dive 315 from the Hatsushima cold-seep site (depth 1170 m, 35°00.0′N and 139°13.8′E) in Sagami Bay, Japan, on 19 November 1987. Copepods were found on the gills of the bivalves and were collected using a small pipette with a tip diameter of 2.0–2.5 mm. Specimens were fixed in 10% formalin and preserved in 80% ethanol.

Copepods were dissected and examined in lactic acid under a stereo- and a compound microscope. Body length was measured from the anterior border of the prosome to the posterior edge of the caudal rami. Segment lengths were measured along the dorsal midline; widths were given as maxima unless otherwise stated. The segments of the first antenna were measured along their posterior, non-setose margins. All drawings were made with the aid of a camera lucida. The text abbreviations are: l = length, w = width, P1–P4 = leg 1–leg 4, exp = exopod, and enp = endopod. In the armature formulae of legs 1–4, Roman and Arabic numerals caps represent spines and setae, respectively.

Family Clausidiidae Embleton, 1901
Genus *Hyphalion* Humes, 1987
Hyphalion sagamiense, new species
Figs. 1–4

Material examined.—40 ovigerous females, 2 males, 1 copepodite. Types deposited in National Science Museum (NSMT), Tokyo, Japan. Holotype female, NSMT-Cr 10159; allotype male, NSMT-Cr 10160; paratype 34 females, NSMT-Cr 10161. Additional materials deposited in Plankton Division, Ocean Research Institute, University of Tokyo and Faculty of Fisheries, Kagoshima University.

Habitat.—Gills of *Calyptogena soyoae* Okutani, 1957.

Locality.—Hatsushima cold-seep site, Sagami Bay, Japan.

Description–Female.—Body (Fig. 1a, b) elongate, flattened; body surface smooth. Total length 2.01 mm, greatest width 0.63 mm. Greatest dorsoventral thickness 0.28 mm. Length ratio of prosome to urosome 1.21:1.

Prosome consisting of 4 somites. Ratio of length to width of prosome 1.69:1. Somite bearing leg 1 fused with cephalosome; cephalothorax 532 × 628 μm (l × w). Somites bearing legs 2, 3, and 4 decreasing in width posteriorly: 161 × 544, 188 × 466, 140 × 388 μm (l × w). Epimeral areas of pedigerous somites rounded.

Urosome with 4 somites. Somite bearing leg 5 (Fig. 1c) 112 × 321 μm (l × w). Genital somite, much broader than long in dorsal view 180 × 312 μm (l × w); its lateral margins expanded. Genital areas located dorsolaterally on expanded portions of somite (Fig. 1d); each area with 2 small smooth setae, 24 μm and 26 μm. Four abdominal somites: 154 × 231, 112 × 199, 96 × 157, and 81 × 151 μm (l × w). Anal somite (Fig. 1e) with 4 broad anteroventral striated scales from right to left 15 × 10, 15 × 13, 16 × 12, 17 × 15 μm (l × w); each posteroventral corner (Fig. 1f) with a single row of spinules.

Caudal ramus (Fig. 1c) longer than wide, 184 × 65 μm (l × w), ratio of length to width 2.83:1. Ramus armed with 6 setae: outer lateral seta 43 μm; dorsal seta 67 μm; innermost terminal seta 82 μm; two long median terminal setae 207 μm (outer) and 395 μm (inner); all these setae smooth. Outermost terminal seta minutely barbed and 111 μm.

Egg sac containing 2 eggs (Fig. 1g). Egg approximately 280 × 250 μm (4 eggs measured).

Rostrum (Fig. 2a) broad, posterior margin rounded without ornamentation. First antenna (Fig. 2b) 7-segmented. Length of each segment: 57, 74, 31, 43, 26, 29, and 43 μm, with formula for armature: 5, 15, 6, 3, 5, 2 + 1 aesthete, and 7 + 1 aesthete, respectively. All setae smooth except some of those on segments 4–7 with minute barbules. Second antenna (Fig. 2c) 3-segmented. First and second segments with single seta. Third segment recurved, with 3 inner subterminal setae, 1 inner terminal seta, 1 outer terminal seta and 3 very long, recurved, sickle-shaped, terminal claws, longest 228 μm. All setae and claws smooth. Claws of both sides forming a strong prehensile structure.

Labrum (Fig. 2d) broad, 59 × 106 μm (l

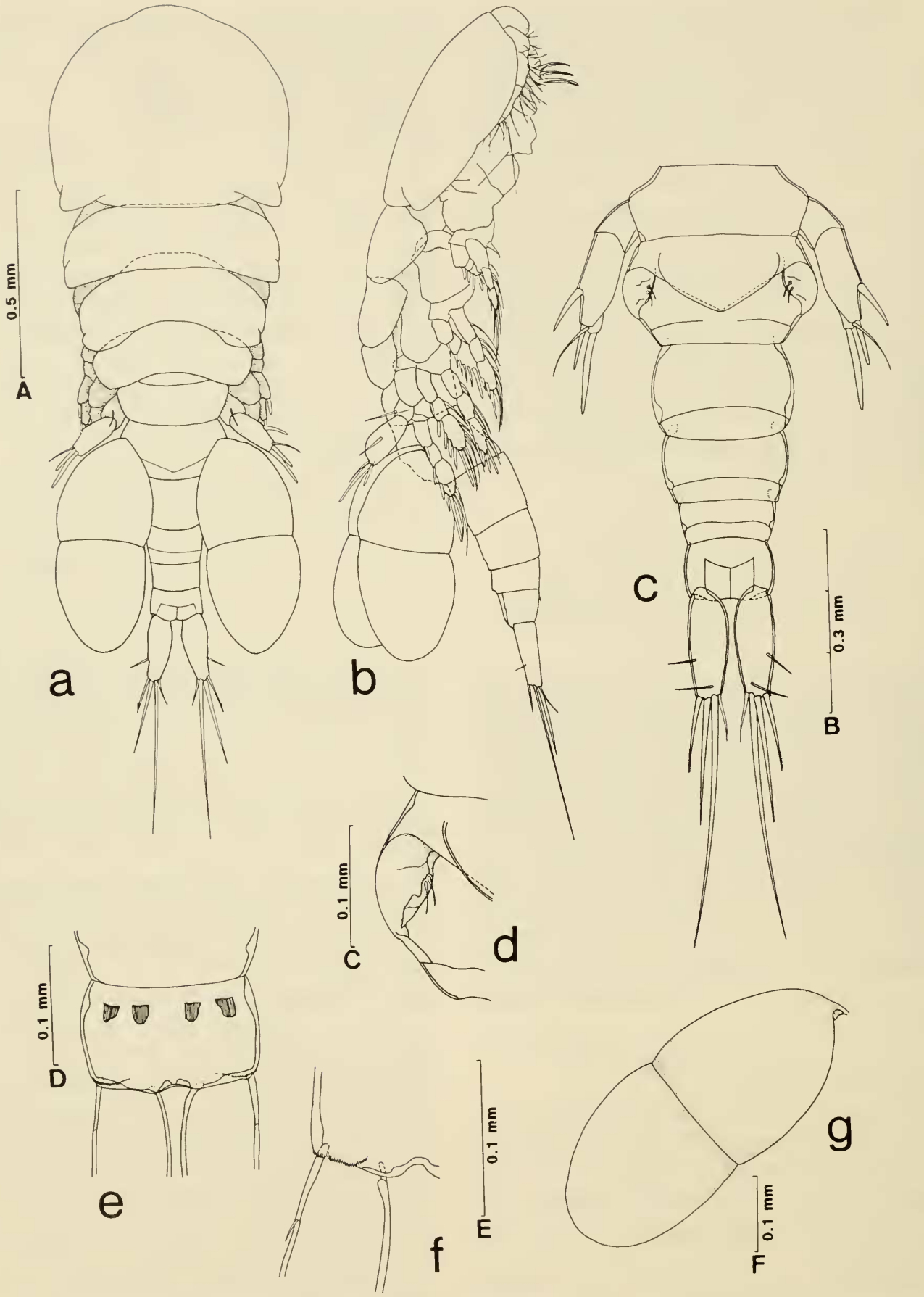

Fig. 1. *Hyphalion sagamiense,* new species. Female: a, dorsal (scale A); b, lateral (A); c, urosome, dorsal (B); d, genital area, dorsal (C); e, anal segment, ventral (D); f, right side of anal segment, ventral (E); g, egg sac, dorsal (F).

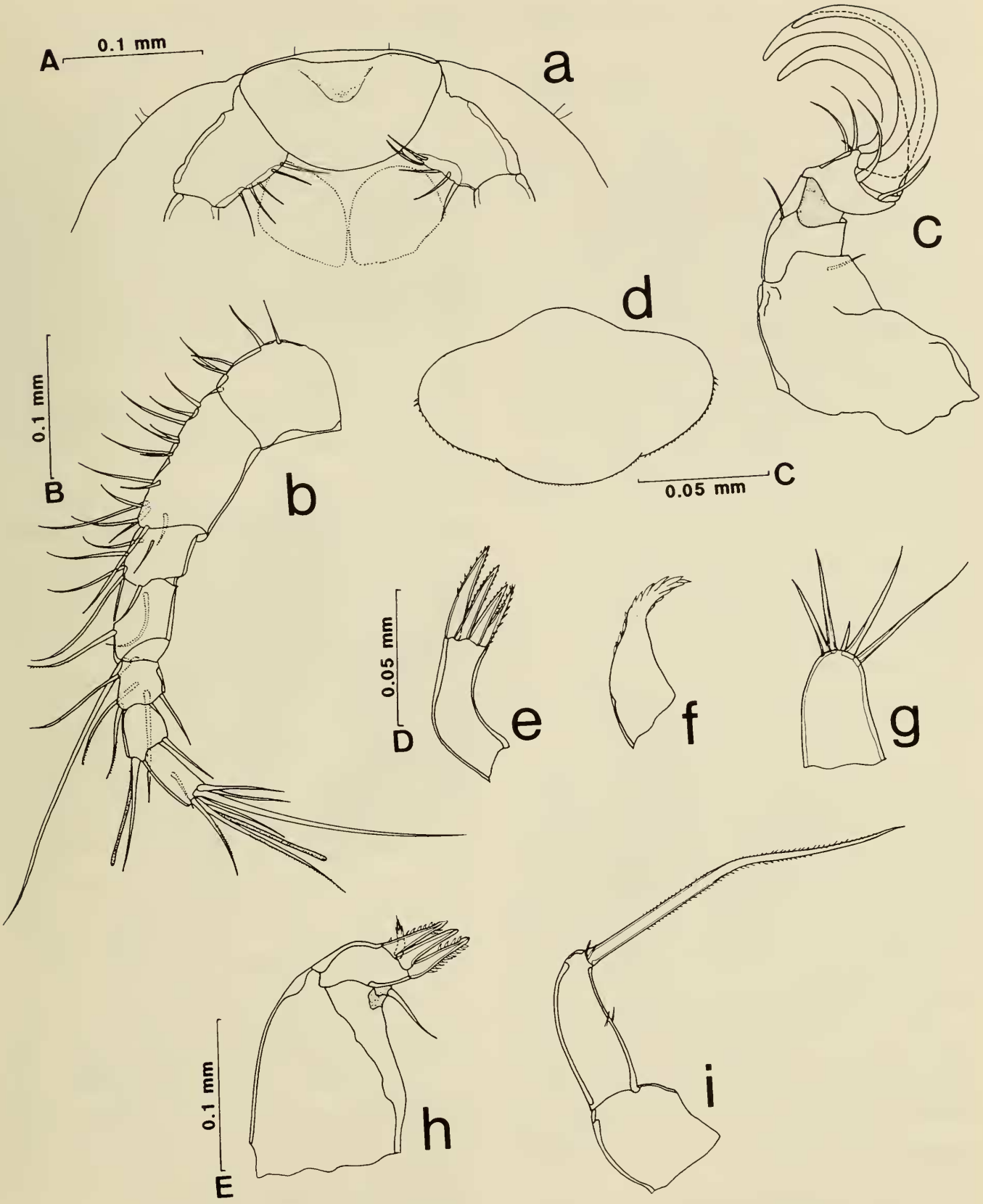

Fig. 2. *Hyphalion sagamiense,* new species. Female: a, rostral area, ventral (scale A); b, first antenna, dorsal (B); c, second antenna (B); d, labrum, ventral (C); e, mandible (D); f, paragnath (D); g, first maxilla (D); h, second maxilla (E); i, maxilliped (E).

× w), with posteroventral rounded margin bearing small spinules.

Mandible (Fig. 2e) flexed, bearing 4 barbed spines terminally. Paragnath (Fig. 2f) falciform with denticulated terminal part. First maxilla (Fig. 2g) digitiform with 5 smooth setae: 4 long setae and 1 middle short seta. Second maxilla (Fig. 2h) 2-segmented. First segment massive with 1 delicate seta. Second segment smaller with 3 spinulose spines, and 1 haired seta. Maxilliped (Fig. 2i) 2-segmented. First segment unarmed. Second segment with 2 very small inner setae, 2 small terminal setules and 1 very long prominent barbed seta. Last seta slightly bent beyond midlength, 228 μm.

Legs 1–4 (Fig. 3a–d) biramous with 3-segmented rami. Armature as follows:

P1 coxa 0-1 basis 1-I	exp I-0; I-1; III, I, 4
	enp 0-1; 0-1; I, 5
P2 coxa 0-1 basis 1-0	exp I-0; I-1; III, I, 5
	enp 0-1; 0-2; II, I, 3
P3 coxa 0-1 basis 1-0	exp I-0; I-1; III, I, 5
	enp 0-1; 0-2; II, II, 2
P4 coxa 0-1 basis 1-0	exp I-0; I-1; II, I, 5
	enp 0-1; 0-2; I, III, 1

Intercoxal plate of leg 1 smooth, those of legs 2–4 with small spinules on surface. Inner seta on coxa of all 4 legs sword-shaped and haired. Inner spine on basis of leg 1 stout and minutely barbed 56 μm long. Leg 5 (Fig. 3e) 2-segmented. First segment 78 × 75 μm, with a single dorsal seta 90 μm. Second segment 113 × 82 μm, ratio 1.38:1, with outer marginal spine 75 μm, subterminal spine 77 μm, terminal spine 131 μm and terminal seta 81 μm. All 3 spines barbed, seta smooth. Leg 6 probably represented by presence of 2 setae in genital area (Fig. 1c, d).

Color of living specimens red.

Male.—General form (Fig. 4a) similar to that of female. Total length 1.42 mm, greatest width 0.47 mm, and greatest dorsoventral thickness 0.23 mm. Length ratio of prosome to urosome 1.30:1.

Prosome consisting of 4 somites. Ratio of length to width of prosome 1.90:1. Cephalothorax 445 × 465 μm (l × w). Somites with legs 2, 3, and 4: 147 × 398, 145 × 330, 89 × 260 μm (l × w).

Urosome with 5 somites, less than in female. Somite bearing leg 5 51 × 167 μm. Genital somite longer than wide, 204 × 174 μm. Posteroventral lappets (Fig. 4b) on genital somite semicircular, not prominent. Lappet with 1 seta minutely barbed, 66 μm. Three postgenital somites from anterior to posterior 137 × 156, 110 × 129, and 88 × 105 μm (l × w). Anal somite with 4 ventral scales as in female.

Caudal ramus similar to that of female, but slightly shorter in male, 134 × 47 μm, ratio 2.85:1.

Rostrum, second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla like those of female. First antenna (Fig. 4c) 7-segmented. Length of each segment: 36, 63, 33, 38, 20, 25, and 39 μm, with formula or armature: 5, 15, 6, 4, 5, 2 + 1 aesthete, and 7 + 1 aesthete, respectively. Maxilliped (Fig. 4d) 3-segmented (assuming claw to represent third segment). First segment with 1 inner smooth seta. Large triangular second segment with inner surface having 1 small setae, and 2 rows of spines (Fig. 4e). Claw (Fig. 4d, e) recurved, 149 μm, bearing 2 unequal, proximal, smooth setae, and 1 delicate setiform sensory organ, attached to terminal part of claw.

Legs 1–4 as in female. Leg 5 (Fig. 4f) similar to that of female. First segment 65 × 53 μm, with dorsal seta 65 μm. Second segment more slender than in female, 91 × 48 μm, ratio 1.90:1, outer marginal spine 56 μm, subterminal spine 55 μm, terminal spine 105 μm, and seta 71 μm. Leg 6 (Fig. 4b) consisting of posteroventral flap on genital segment with 1 pinnate seta.

Color of living specimens red.

Etymology.—This species has been named after its sampling site, Sagami Bay.

Remarks.—Several features of the new species conform to the genus *Hyphalion* Humes, 1987: the habitus, the urosome with

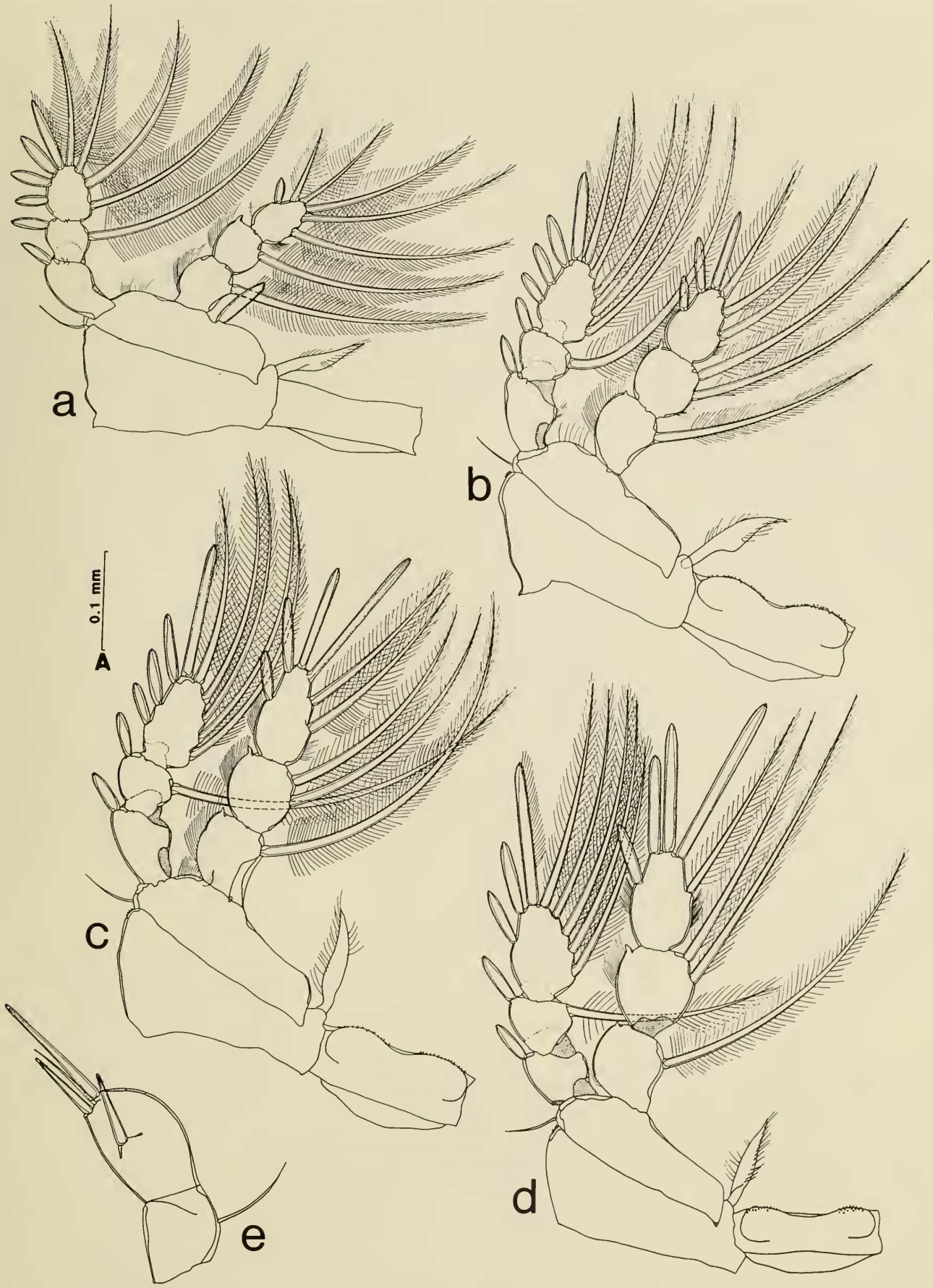

Fig. 3. *Hyphalion sagamiense,* new species. Female: a, leg 1 and intercoxal plate, anterior (scale A); b, leg 2 and intercoxal plate, anterior (A); c, leg 3 and intercoxal plate, anterior (A); d, leg 4 and intercoxal plate, anterior; e, leg 5, left, anterior (A).

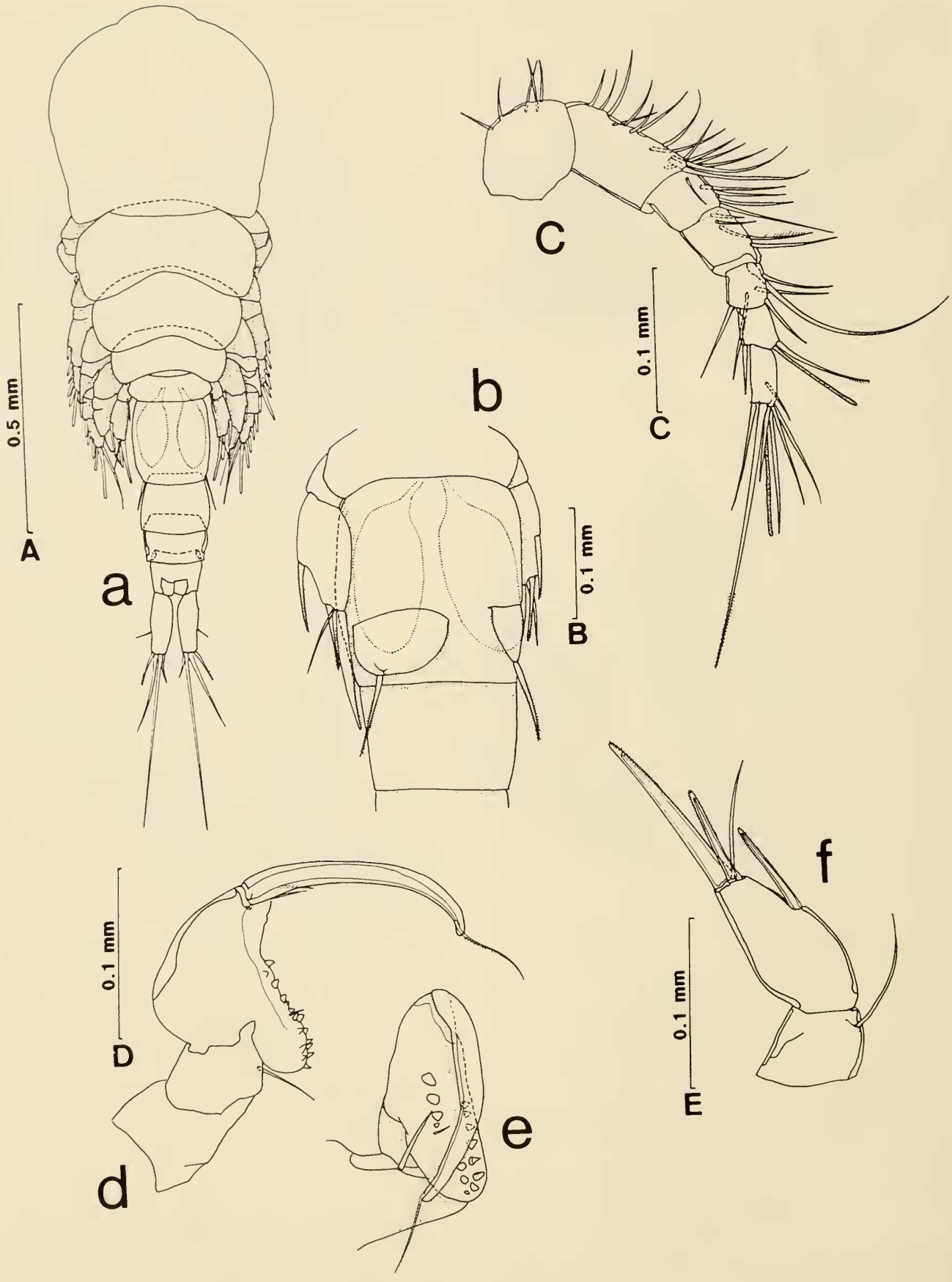

Fig. 4. *Hyphalion sagamiense,* new species. Male: a, dorsal (scale A); b, genital segment, legs 5 and 6, ventrolateral (B); c, first antenna (C); d and e, maxilliped (D); f, leg 5, dorsal (E).

6 somites in the female and 5 in the male, the 3-segmented prehensile second antenna with 3 strongly recurved claws, the mandible with 4 elements, the first maxilla with 5 setae, the 2-segmented second maxilla consisting of a large first segment with 1 seta and small second segment with 3 spines and 1 seta, the 2-segmented maxilliped of the female with the second segment having an extremely long seta, and the spinal and setal formulae on legs 1–5. However, *Hyphalion sagamiense* may be distinguished from its only congener, *H. captans* by the following characters: (1) The first antenna is 7-segmented; the third segment of *H. captans* corresponds to third and fourth segments of *H. sagamiense,* judging from the proportions and the ornamentation; (2) the tapering paragnath has a spinose tip; (3) the second segment of leg 5 is broad, and the length to width ratio is 1.38:1 in the female and 1.90:1 in the male, but in *H. captans,* 2.23:1 and 2.43:1, respectively; (4) the length to width ratios of the caudal rami are 2.83:1 and 2.85:1 in female and male, respectively, but in *H. captans* 3.17:1 and 3.15:1; (5) the male maxilliped is 3-segmented; (6) the long terminal claw of the male maxilliped has a delicate apical seta presumed to be a sensory organ.

Discussion

Hyphalion sagamiense is the first copepod described from deep-sea cold-seep sites in the western Pacific. On the other hand, its only congener *Hyphalion captans* was collected from Guaymas Basin, Gulf of California. Although these two copepods occurred separately on either side of the Pacific Ocean, they are very similar in several features such as body form, second antenna, mandible, first maxilla, second maxilla, and maxilliped. Additionally, the spinal and setal formulae on legs 1–5 in *H. captans* and *H. sagamiense* are the same; consequently, these two species are considered to be closely allied. The discovery of the new species validated the original establishment of the genus *Hyphalion* proposed by Humes (1984) for the type-species *H. captans,* and helped to more clearly define the genus. The generic definition was partially emended in order to accommodate the new species. The presence of the 7-segmented first antenna and the 4-segmented maxilliped of the male was added to the original generic diagnosis.

The family Clausidiidae currently consists of nine genera included by Vervoort & Ramirez (1966) and three genera proposed afterwards: *Clausidium* Kossmann, 1874, *Conchyliurus* Bocquet & Stock, 1957a, *Cotylomolgus* Humes & Ho, 1967, *Giardella* Canu, 1888, *Hemicyclops* Boeck, 1873, *Hersiliodes* Canu, 1888, *Hippomolgus* Sars, 1917, *Hyphalion* Humes, 1987, *Leptinogaster* Pelseneer, 1929, *Myzomolgus* Bocquet & Stock, 1957b, *Pseudopsyllus* T. Scott, 1902, and *Tychidion* Humes, 1973. Presently, among these genera, *Hyphalion* is considered most closely related to *Hemicyclops.* The 7-segmented first antenna of the new species conforms to the character of *Hemicyclops* (6-segmented in the type-species of *Hyphalion*). The minor emendation of the generic definition, therefore, makes the distinction between the two genera a little obscure. However, both species of the genus *Hyphalion* can still be distinguished from *Hemicyclops* and the other genera in the family Clausidiidae by the unusual armature of the second antenna.

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Literature Cited

Bocquet, C., & J. H. Stock. 1957a. Copépodes parasites d'invertébrés des côtes de France. I. Sur deux genres de la famille des Clausidiidae, commensaux de mollusques: *Hersiliodes* Canu et *Conchyliurus* nov. gen.—Proceedings Koninkl. Nederlandse Akademie van Wetenschappen, Ser. C, Biological and Medical Sciences, Amsterdam 60:212–222.

———, & ———. 1957b. Copépodes parasites d'invertébrés des côtes de France. IVa. Le double parasitisme de *Sipunculus nudus* L. par *Myzomolgus stupendus* nov. gen., nov. sp., et *Catinia plana* nov. gen., nov. sp., copépodes cyclopoïdes très remarquables.—Proceedings Koninkl. Nederlandse Akademie van Wetenschappen, Ser. C, Biological and Medical Sciences, Amsterdam 60:410–431.

Boeck, A. 1873. Nye Slaegter og Arter af Saltvands-Copepoder.—Forhandlinger i Videnskabsselskabet i Kristiana 14(1872):35–60.

Canu, E. 1888. Les Copépodes marins du Boulonnais. III. Les Hersiliidae, famille nouvelle de Copépodes commensaux.—Bulletin Scientifique de la France et de la Belgique, Ser. 3, 1:402–432.

Embleton, A. L. 1901. *Goidelia japonica*—a new entozoic copepod from Japan, associated with an infusorian (Trichodina).—Journal of the Linnean Society of London, Zoology 28:211–229.

Fleminger, A. 1983. Description and phylogeny of *Isaacsicalanus paucisetus,* n. gen., n. sp. (Copepoda: Calanoida: Spinocalanidae) from an east Pacific hydrothermal vent site (21°N).—Proceedings of the Biological Society of Washington 96:605–622.

Humes, A. G. 1973. *Tychidion guyanense* n. gen., n. sp. (Copepoda, Cyclopoida) associated with an annelid off Guyana.—Zoologische Mededelingen 46(14):189–196.

———. 1984. *Benthoxynus spiculifer* n. gen., n. sp. (Copepoda: Siphonostomatoida) associated with Vestimentifera (Pogonophora) at a deep-water geothermal vent off the coast of Washington.—Canadian Journal of Zoology 62:2594–2599.

———. 1987. Copepoda from deep-sea hydrothermal vents.—Bulletin of Marine Science 41:645–788.

———. 1988a. *Oncaea praeclara* n. sp. (Copepoda: Poecilostomatoida) from deep-sea hydrothermal vents in the eastern Pacific.—Journal of Plankton Research 10:475–485.

———. 1988b. *Bythocheres prominulus,* a new genus and species (Copepoda: Siphonostomatoida) from deep-water cold seeps at the West Florida Escarpment.—Proceedings of the Biological Society of Washington 101:568–575.

———. 1988c. *Hyalopontius boxshalli,* new species (Copepoda: Siphonostomatoida), from a deep-sea hydrothermal vent at the Galapagos Rift.—Proceedings of the Biological Society of Washington 101:825–831.

———. 1988d. Copepoda from deep-sea hydrothermal vents and cold seeps.—Hydrobiologia 167/168:549–554.

———. 1989a. *Rhogobius pressulus* n. sp. (Copepoda: Siphonostomatoida) from a deep-sea hydrothermal vent at the Galapagos Rift.—Pacific Science 43:27–31.

———. 1989b. New Species of *Stygiopontius* (Copepoda: Siphonostomatoida) from a deep-sea hydrothermal vent at the East Pacific Rise.—Zoologica Scripta 18(1):103–113.

———. 1989c. A new poecilostomatoid copepod (Erebonasteridae) from deep-sea cold seeps at the West Florida Escarpment.—Hydrobiologia 175:175–182.

———. 1989d. Copepoda from deep-sea hydrothermal vents at the East Pacific Rise.—Bulletin du Muséum national d'Histoire naturelle, Paris, 4e ser. 11, Section A, no 4:829–849.

———. 1990. Copepods (Siphonostomatoida) from a deep-sea hydrothermal vent at the Mariana Back-Arc Basin in the Pacific, including a new genus and species.—Journal of Natural History 24:289–304.

———, & M. Dojiri. 1980a. A new siphonostome family (Copepoda) associated with a vestimentiferan in deep water off California.—Pacific Science 34:143–151.

———, & M. Dojiri. 1980b. A siphonostome copepod associated with a vestimentiferan from the Galapagos Rift and the East Pacific Rise.—Proceedings of the Biological Society of Washington 93:697–707.

———, & J.-S. Ho. 1967. New cyclopoid copepods associated with polychaete annelids in Madagascar.—Bulletin of the Museum of Comparative Zoology 135(7):377–413.

Kossmann, R. 1874. Ueber *Clausidium testudo,* einen neuen Copepoden, nebst Bemerkungen uber das System der halbparasitischen Copepoden.—Verhandlungen der Physikalisch-Medizinischen Gesellschaft zu Wurzberg. N.F. (new series) 7:280–294.

Miura, T. 1988. Parasitic animals collected in a *Calyptogena*-dominant community developing off the Hatsushima, the Sagami Bay.—Technical Reports of Japan Marine Science and Technology Center. The 4th Symposium on Deep-sea Research using the Submersible "SHINKAI 2000" System—Special Issue (1988):239–244. [In Japanese with English abstract]

———, & L. Laubier. 1990. Nautiliniellid polychaetes collected from the Hatsushima cold-seep

site in Sagami Bay, with descriptions of new genera and species.—Zoological Science 7:319–325.

Okutani, T. 1957. Two new species of bivalves from the deep water in Sagami Bay collected by the R. V. *Soyo-Maru.*—Bulletin of Tokai Regional Fisheries Research Laboratory 17:27–30.

———, & K. Egawa. 1985. The first underwater observation on living habit and thanatocoenosis of *Calyptogena soyoae* in bathyal depth of Sagami Bay.—Venus (Japanese Journal of Malacology) 44(4):285–288.

Pelseneer, P. 1929. Copépodes parasites de Mollusques.—Annales de la Societe Royale Zoologique de Belgique 59:33–49.

Sars, G. O. 1917. Copepoda Cyclopoida.—An account of the Crustacea of Norway with short descriptions and figures of all the species 6:146–172.

Scott, T. 1902. Notes on gatherings of Crustacea collected by the fishery steamer "Garland" and the steam trawlers "Star of Peace" and "Star of Hope", of Aberdeen, during the year 1901.—Annual Report of the Fishery Board for Scotland 20(3):447–484.

Vervoort, W., & F. Ramirez. 1966. *Hemicyclops thalassius* nov. spec. (Copepoda, Cyclopoida) from Mar del Plata, with revisionary notes on the family Clausidiidae.—Zoologische Mededelingen 41(13):195–220.

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